Statistical Physics of geophysical Extreme Events

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How to model complex systems? Complex is what we perceive as spatially, temporally and dynamically rich and esthetically beautiful. This richness is declined in the shapes of turbulent vortices, the rage of a storm, the exponentially fast diffusion of a virus or an economic crisis. In this talk, I will take the point of view of statistical physics and dynamical systems theory to illustrate mathematical tools that act as magnifying glasses for complex systems. One of the outcomes of this investigation is the possibility of studying some of the most complex systems we can figure out, namely an ensemble of turbulent vortices in a confined geometry with just three simple dynamical equations. These equations do not only describe the mean state of the system but they allow for short term predictability of its motion. Another counterintuitive result is that extreme events of the atmospheric circulation such as tropical or extratropical cyclones yield often a simpler structure than the mean behavior of the atmosphere: they act as condensates where all but few degrees of freedom of the dynamics are frozen. Equipped with these statistical tools, we can search the footprint of unstable fixed points in natural phenomena and discover their correspondence with extreme events encountered in the everyday life [1].

References

[1] Faranda, D., Alvarez-Castro, M. C., Messori, G., Rodrigues, D., Yiou, P. (2019). The hammam effect or how a warm ocean enhances large scale atmospheric predictability. Nature communications, 10(1), 1-7.